WRAP Alaska Modeling for Regional Haze at Class I Areas

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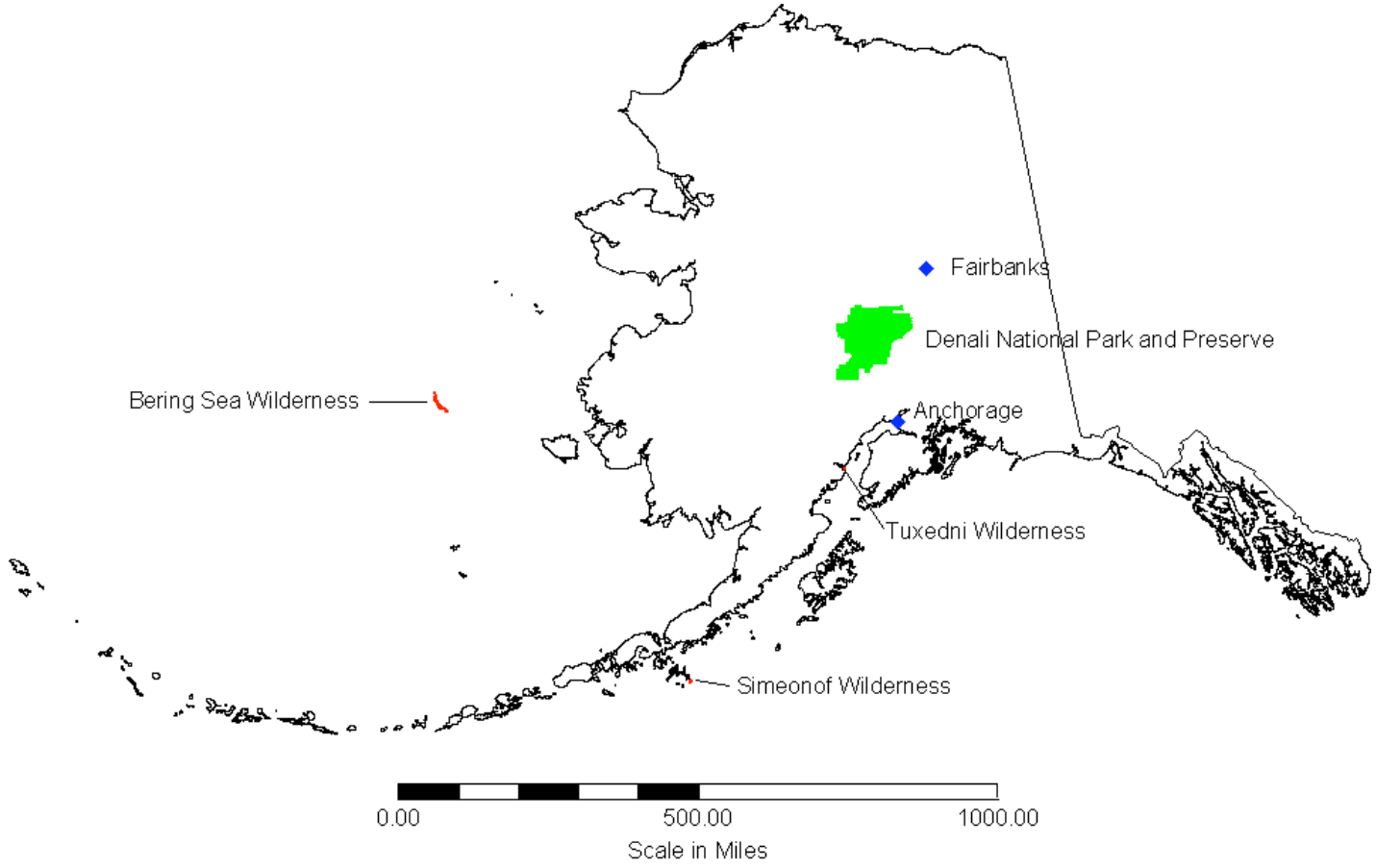
Four Class I Areas in Alaska



WRAP Alaska MM5 Modeling

- **MM5 modeling to support regional haze modeling for year 2002**
- **The State of Alaska is working to develop a statewide emissions inventory**
- **Premature to do photochemical modeling with CMAQ**
- **MM5 will supply meteorological fields to CALMET/ CALPUFF**

Outline

- **Modeling the meteorology of Alaska**
  - **What meteorological modeling skill can we obtain for Alaska?**
- **MM5 Configuration**
- **Results from 2002 annual run**
  - **METSTAT surface analysis of 15 km grid**
  - **Upper air analysis of 45 km grid**

Challenges for Met Modeling of Alaska

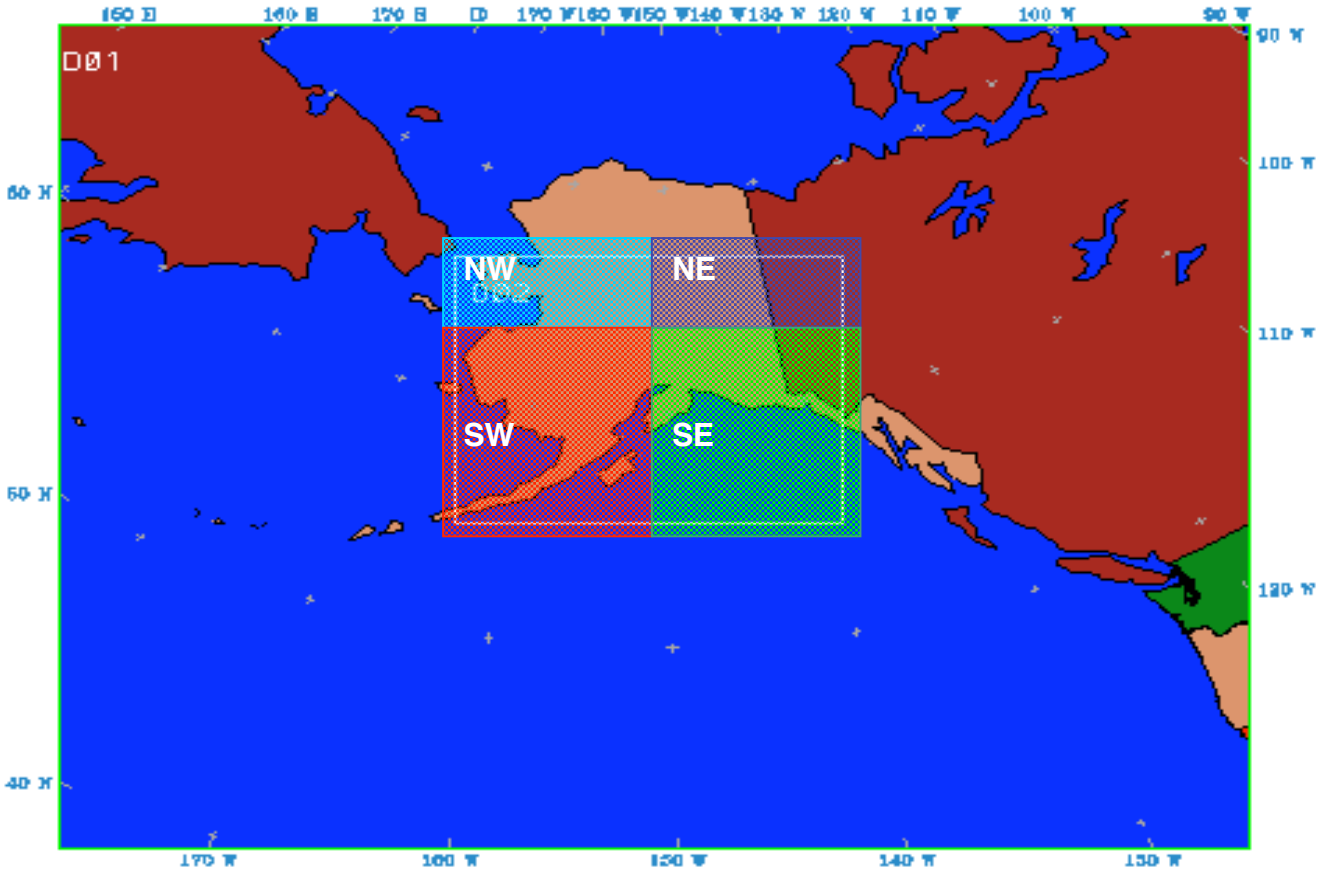
- **Dark, cold, and very dry in winter**
- **Interactions between sea ice and the air not well understood. Sea ice breakup and formation.**
- **Ice and snow undergo strong radiative cooling, which can set up a strong temperature inversion near the surface**
  - This creates an extremely stable boundary layer which can decouple from the flow aloft.
  - It is therefore possible to have air masses with different origins and properties superimposed in the vertical.
- **MM5 does not simulate boundary layer inversions well**

Challenges for Met Modeling of Alaska

(concluded)

- **The MM5 modeled temperature fields are very sensitive to the cloud field; some Arctic clouds have unusual properties.**
  - diamond dust
  - multiple layers of thin cloud
  - convective plumes over gaps in sea ice
- **Alaska is so cold in winter that the some of the physical assumptions underpinning MM5 parameterizations of moist processes may no longer be valid. POLAR option.**
- **Observing network is sparse.**

WRAP Alaska 45 km and 15 km MM5 Domains



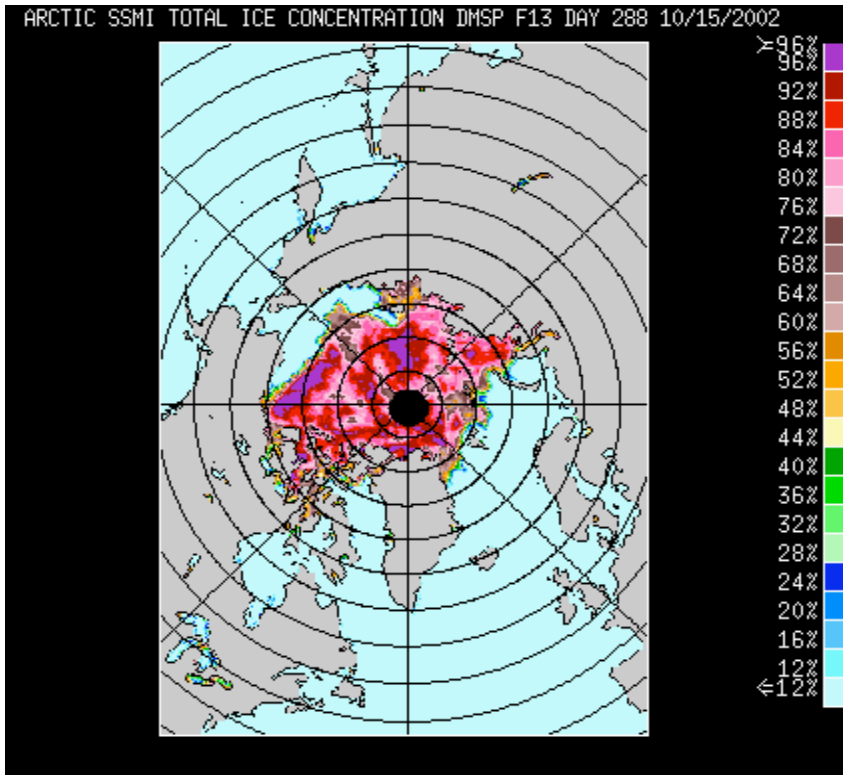
Background on MM5 Configuration for 2002 Annual Run

- **WRAP MM5 configuration based on work of the Mesoscale Modeling and Applications Group at the University of Alaska Fairbanks**
  - **The UAF Group has extensive experience with operational numerical weather prediction in high latitudes using MM5**
- **We started with their setup and performed sensitivity tests to find optimal configuration**

Treatment of Sea Ice

- **When modeling a full year over the Alaska domain, have to account for the annual cycle of sea ice.**
  - **MM5 diagnoses sea ice fraction in a grid cell using the sea surface temperature; this option must be used during the winter months.**
  - **Use of the sea ice option requires the use of the 5-layer land surface scheme. Less detailed than OSU, worse performance during summer.**

Timing of Sea Ice Switch On/Off



- **October 13, 2002: sea ice on**
- **May 30, 2002: sea ice off**

- Gridded sea ice concentrations from passive microwave sounders
- Data from NASA GSFC National Snow and Ice Data Center

Summary of Sensitivity Tests

- **Land Surface Model**
  - Summer: NOAH, Pleim-Xiu
  - Winter: required to use 5-Layer Model
- **PBL**
  - Summer: ETA, Asymmetric Convective Mixing
  - Winter: ETA
- **Radiation**
  - RRTM, CCM2, CLOUD
- **FDDA**
  - Surface obs nudging

MM5 Configuration for 2002 Annual Run

Winter

Physics Option	Parameterization
Cloud Microphysics	Reisner II
Cumulus Parameterization	Grell
Planetary Boundary Layer	ETA
Land Surface Model	**5-Layer Model**
Radiation	RRTM
Shallow Convection	None
Varying SST with time?	Yes
Sea Ice	**Yes**
Snow Cover	**Simple Snow Model**

Summer

Physics Option	Parameterization
Cloud Microphysics	Reisner II
Cumulus Parameterization	Grell
Planetary Boundary Layer	ETA
Land Surface Model	**OSU**
Radiation	RRTM
Shallow Convection	None
Varying SST with time?	Yes
Sea Ice	**No**
Snow Cover	**No**

Method for Evaluating Alaska MM5 2002 Annual 45/15 km Run

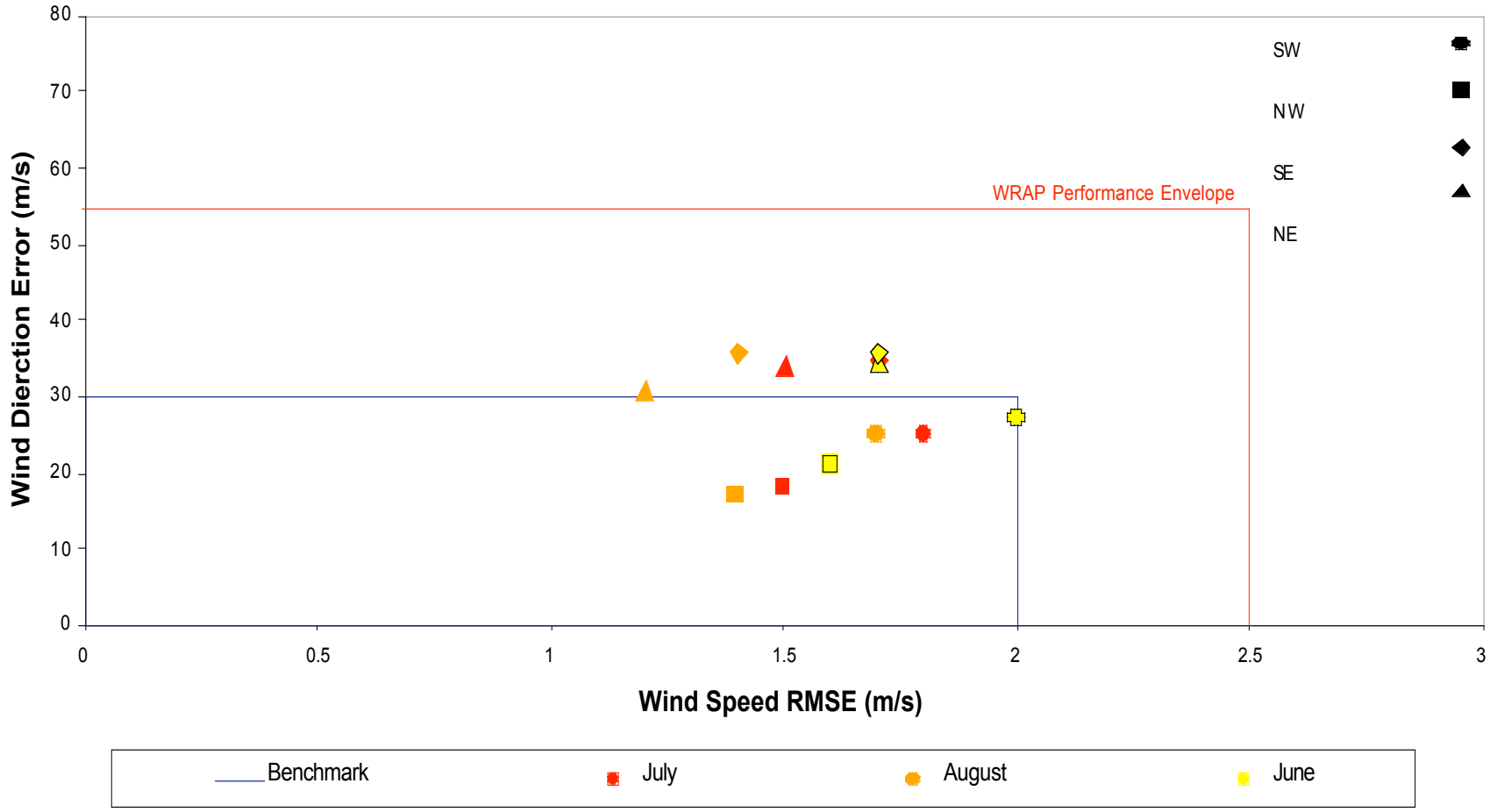
Focusing on 15-km grids, we will examine:

- **Surface statistics for wind, temperature, and humidity**
  -Four Subdomains: SW, NW, NE, SE

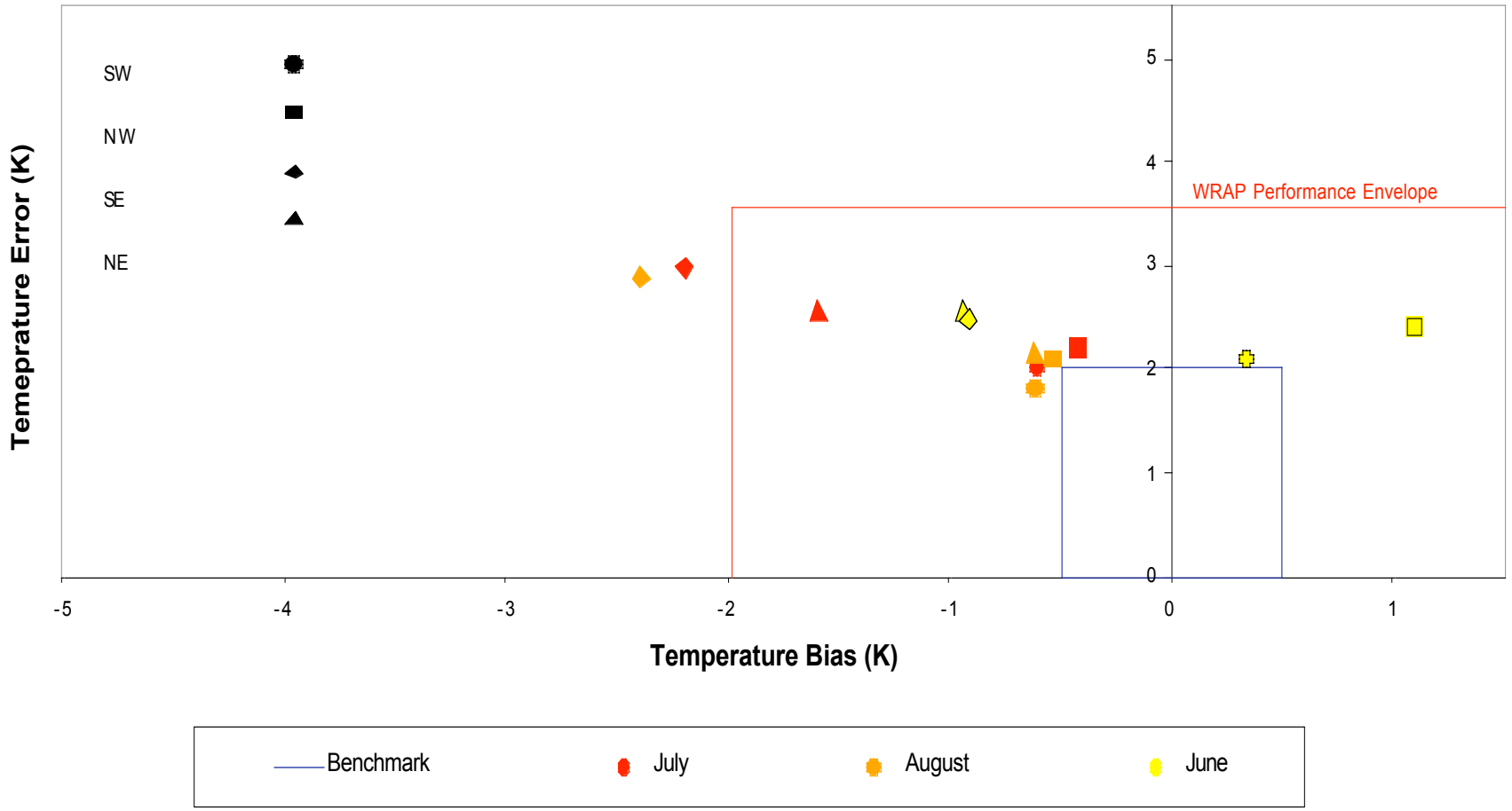
- **Upper air soundings of temperature, dew point, and winds**

and compare with observations.

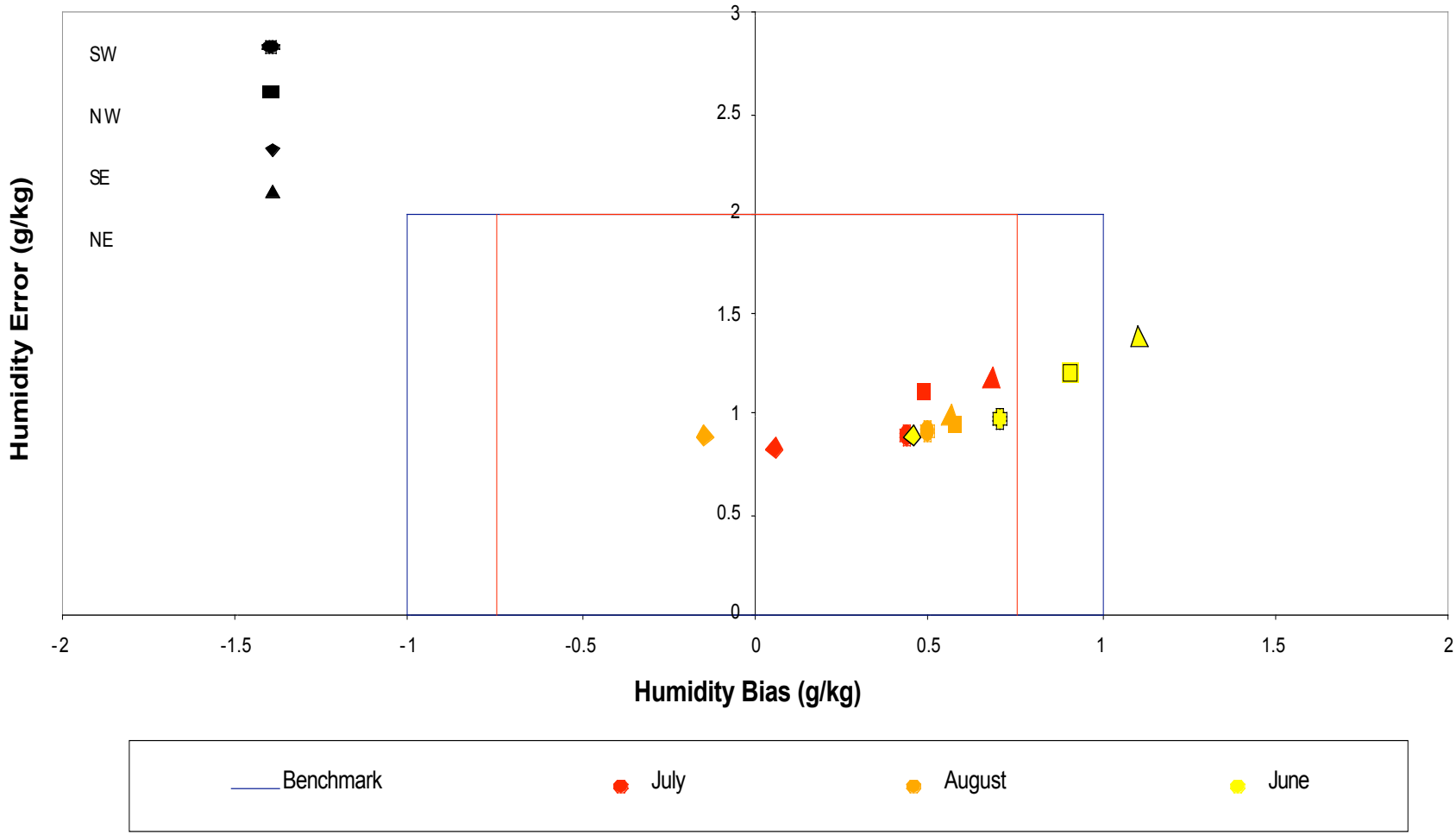
Alaska 15 km Domain Wind Performance Comparison



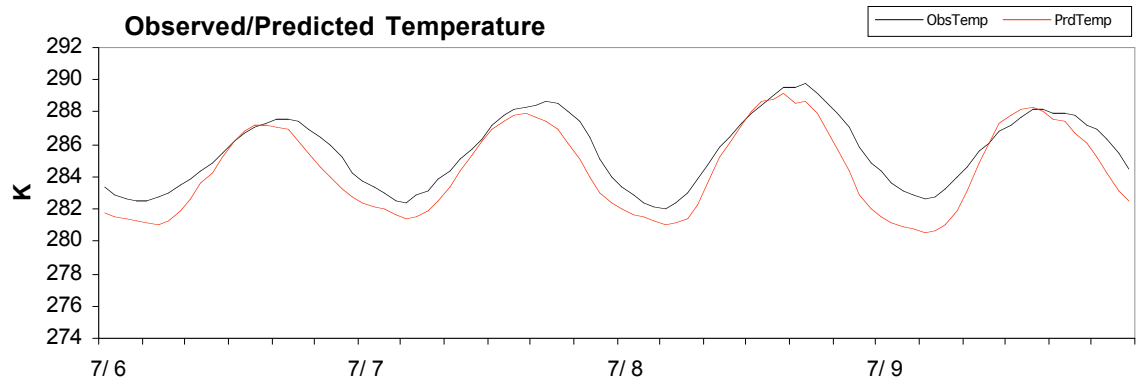
Alaska 15 km Domain Temperature Performance Comparison



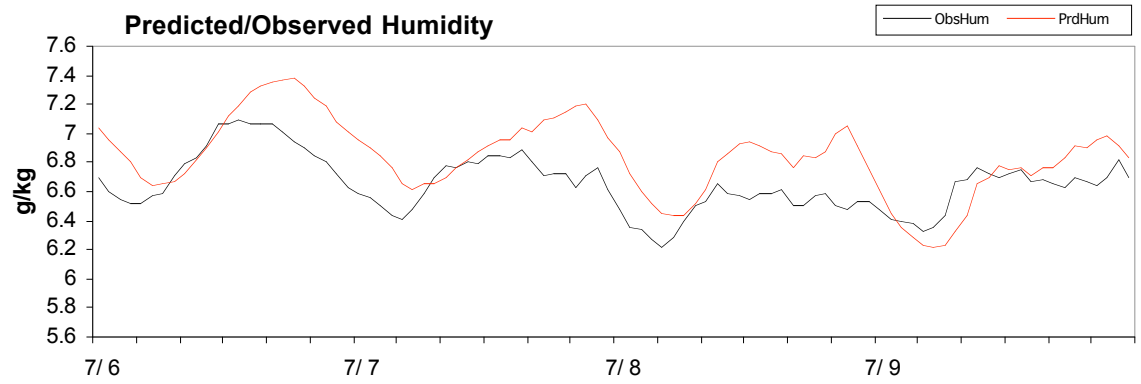
Alaska 15 km Domain Humidity Performance Comparison



Temperature, Humidity Time Series for 15 km Domain for July 6-10

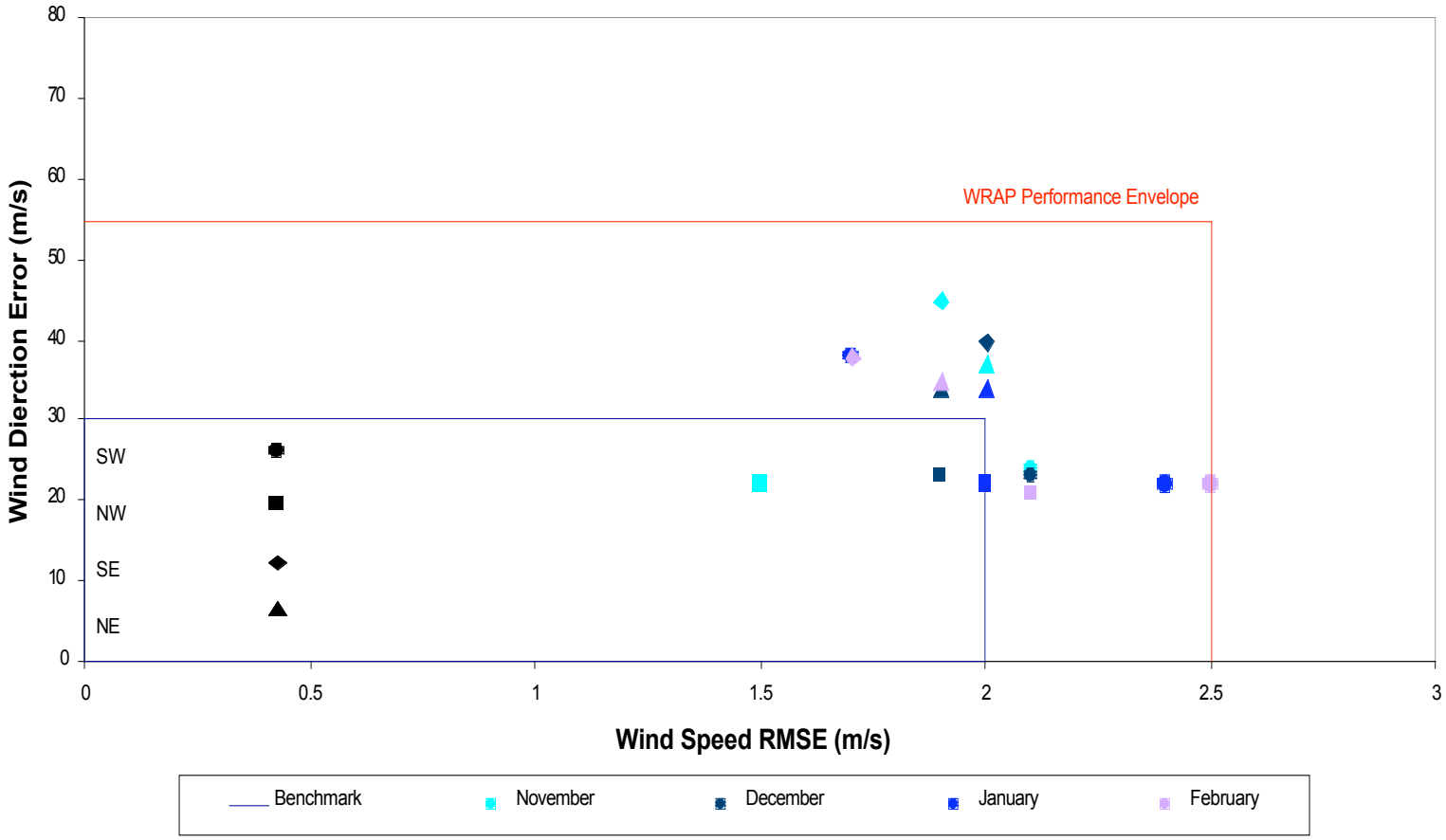


- Temp phase lead
- Cold Bias
- Daily max too low

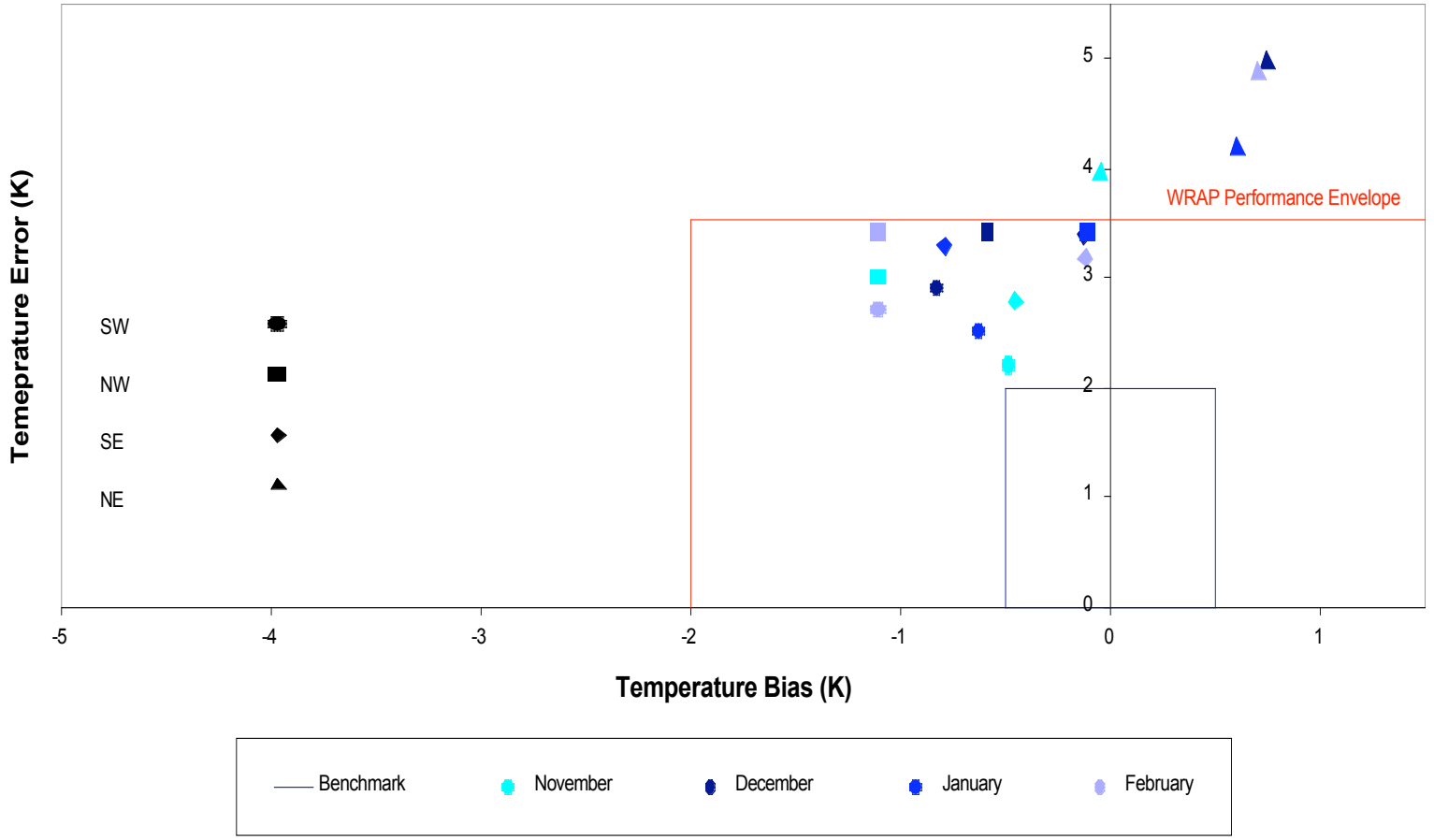


- Humidity phase lag
- Wet bias

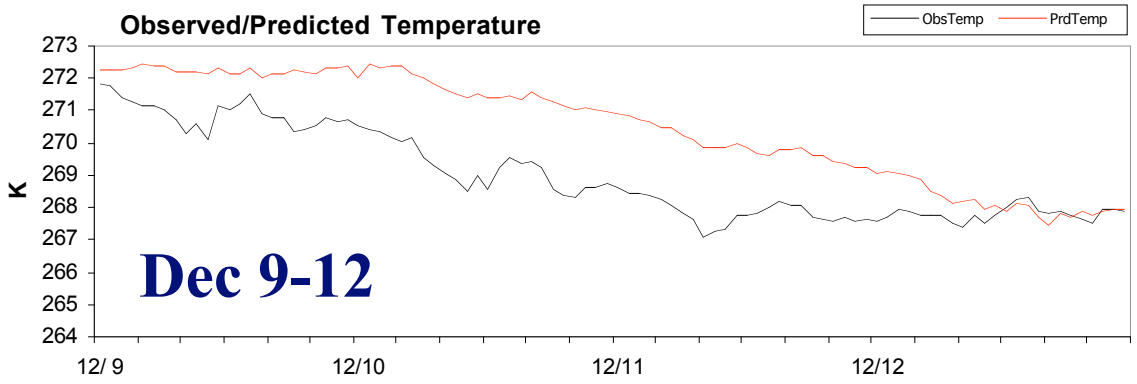
Alaska 15 km Domain Wind Performance Comparison

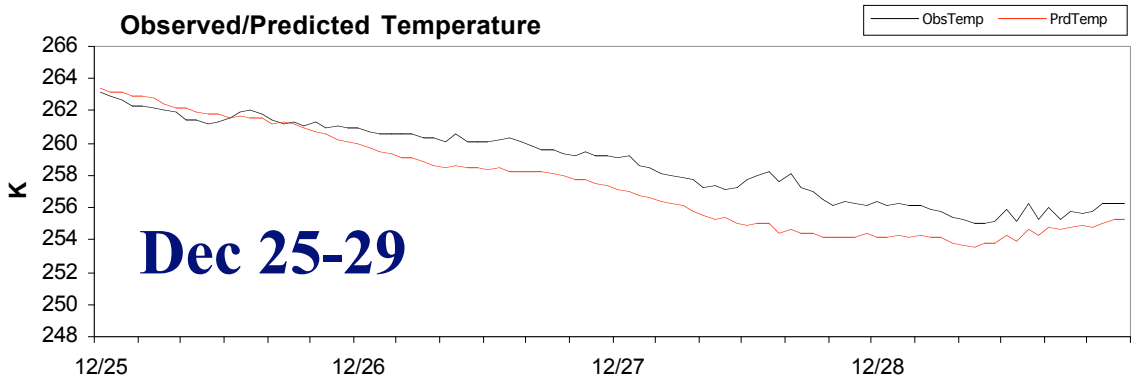


Alaska 15 km Domain Temperature Performance Comparison



Temperature Time Series for 15 km Domain for December





- Lack of diurnal cycle
- Warm bias 1st half
- Cold bias 2nd half
- Small overall bias

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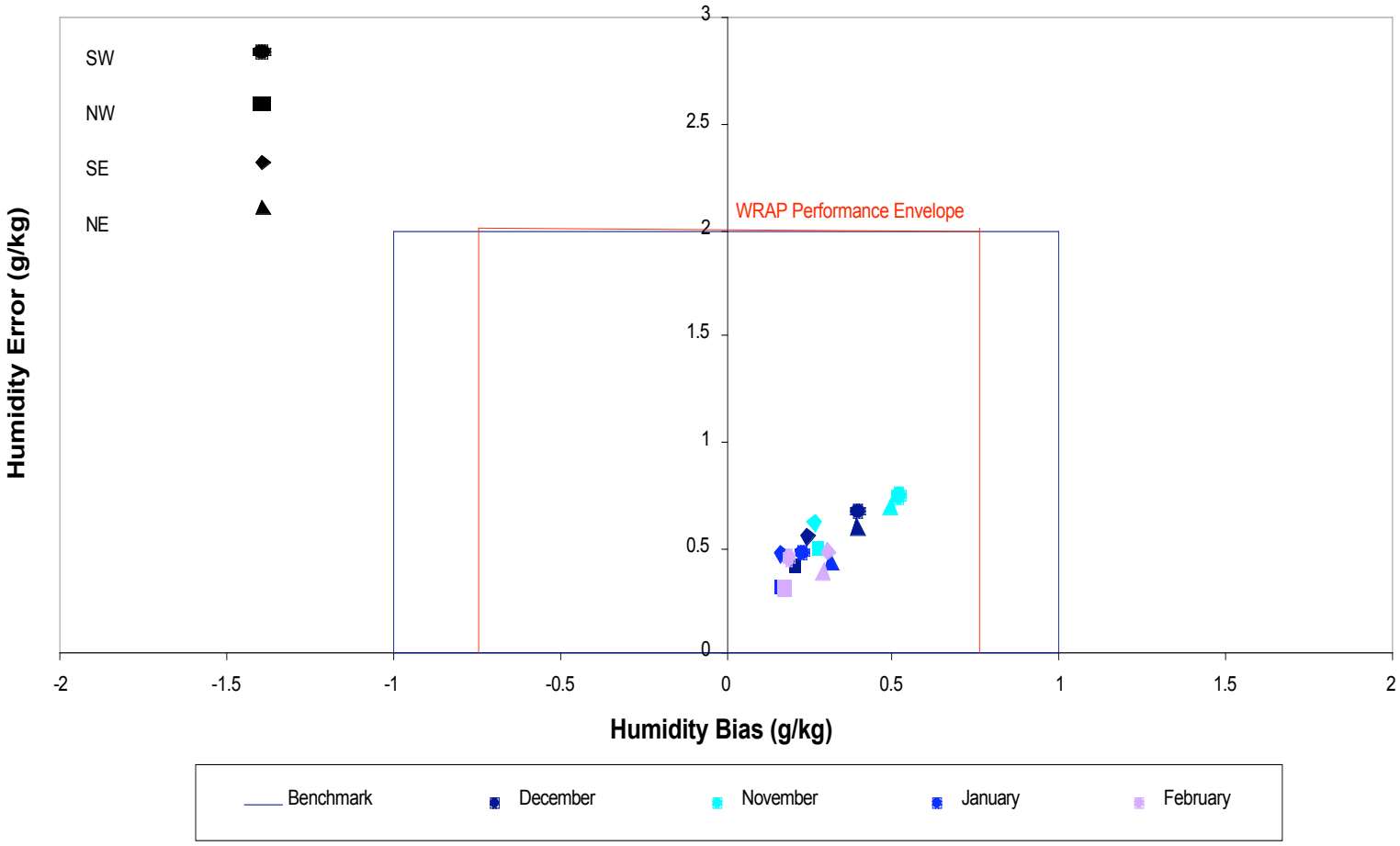
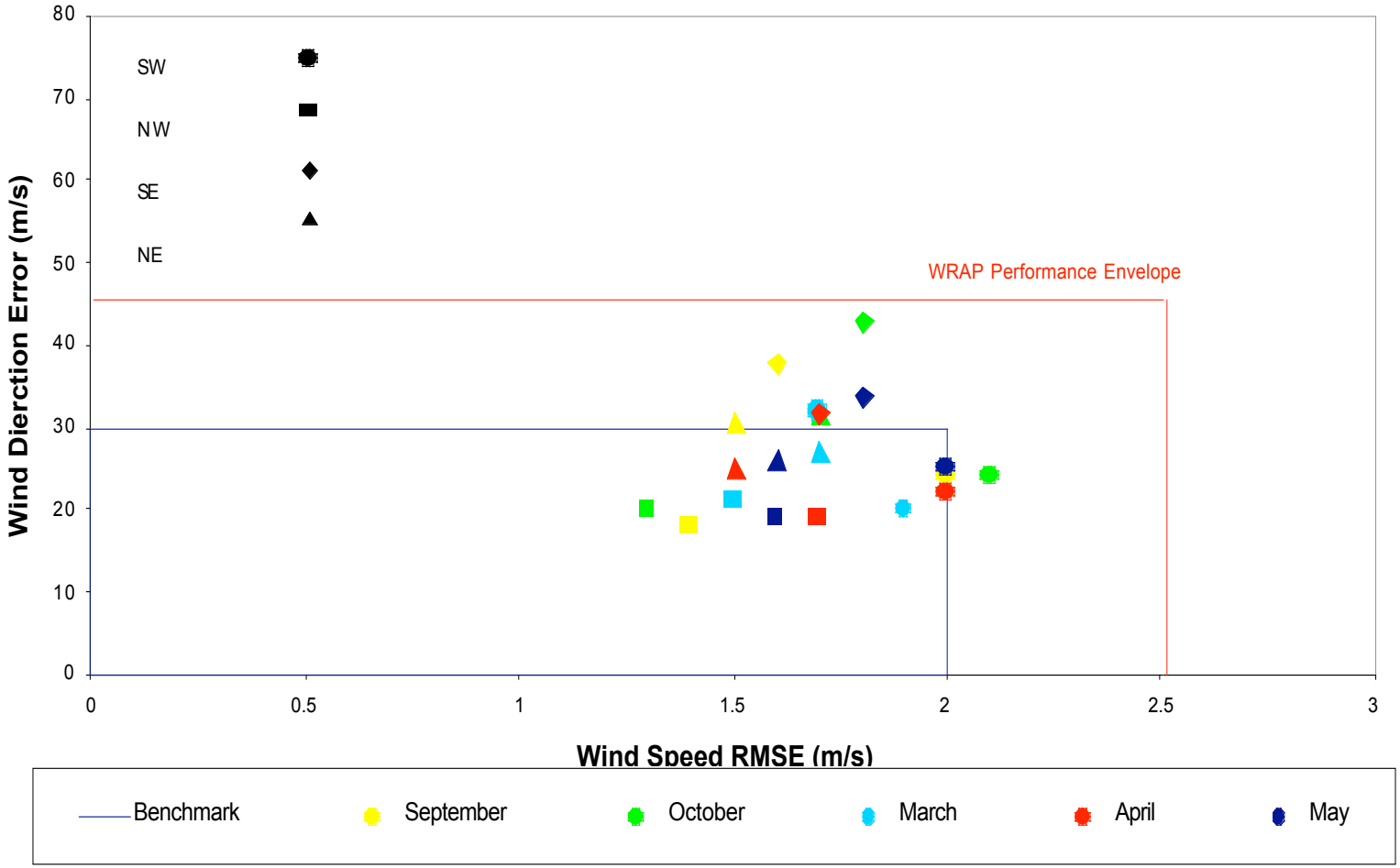
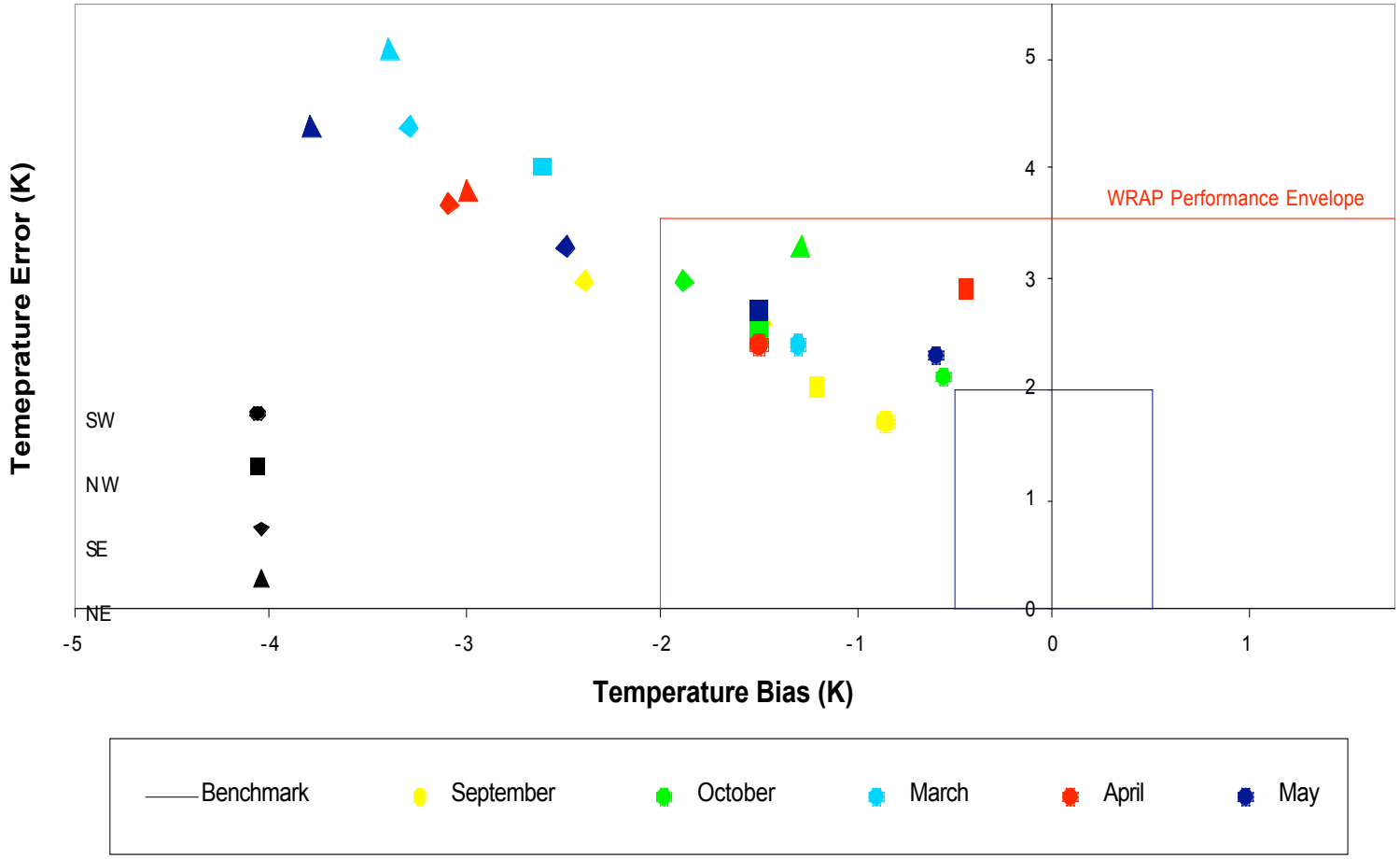
Alaska 15 km Domain Humidity Performance Comparison



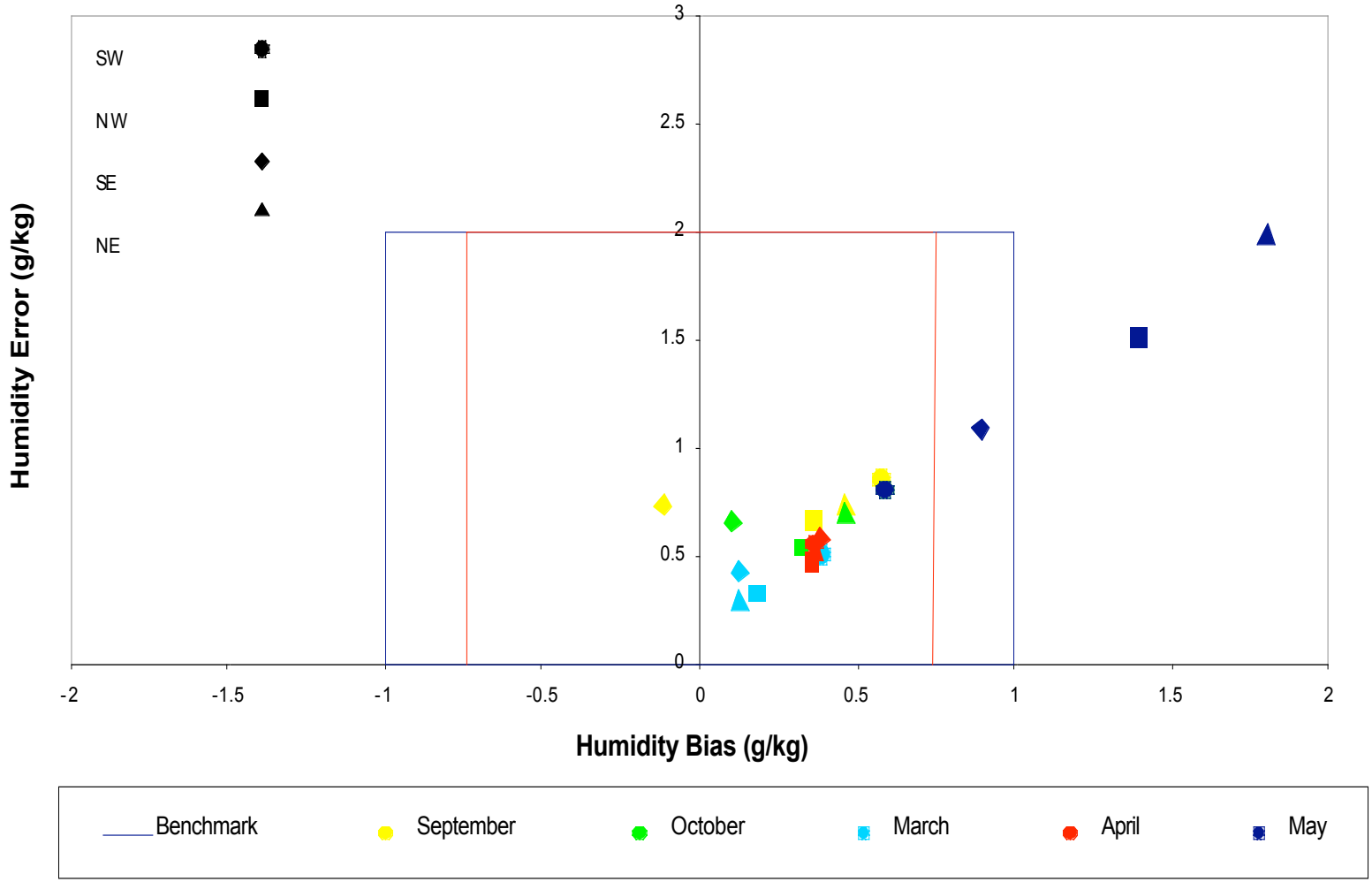
Alaska 15 km Domain Wind Performance Comparison



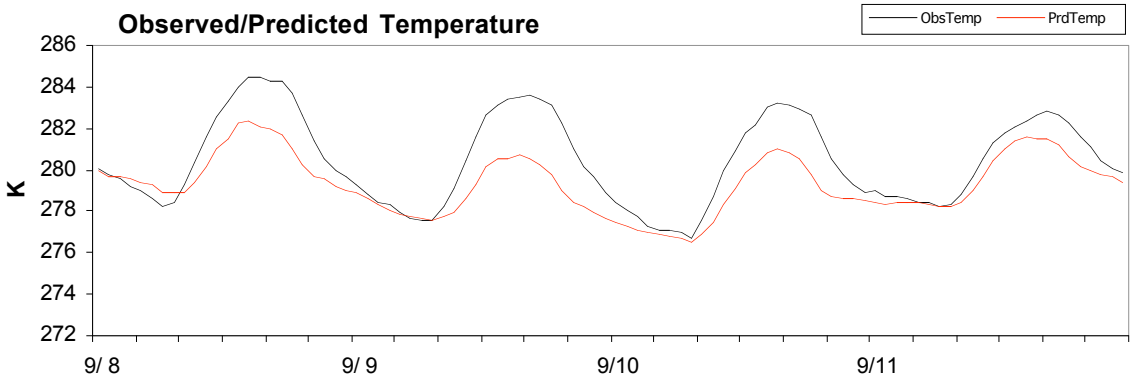
Alaska 15 km Domain Temperature Performance Comparison



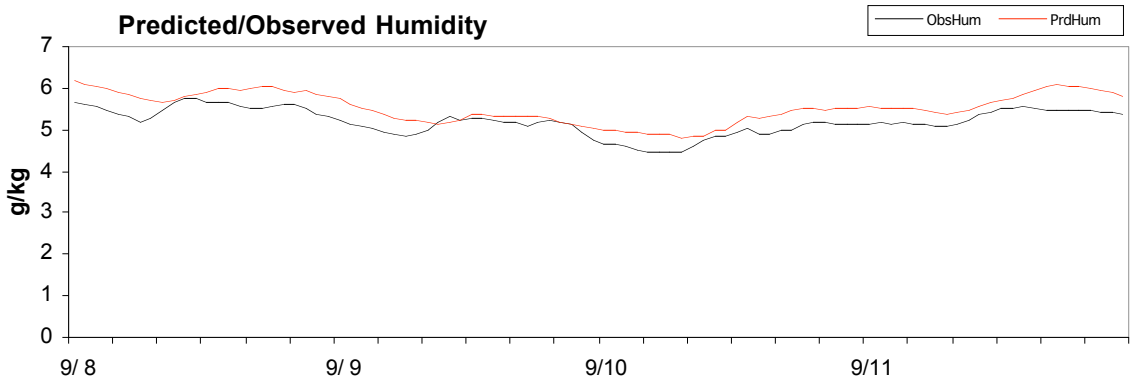
Alaska 15 km Domain Humidity Performance Comparison



Temperature, Humidity Time Series for 15 km Domain for September 8-12

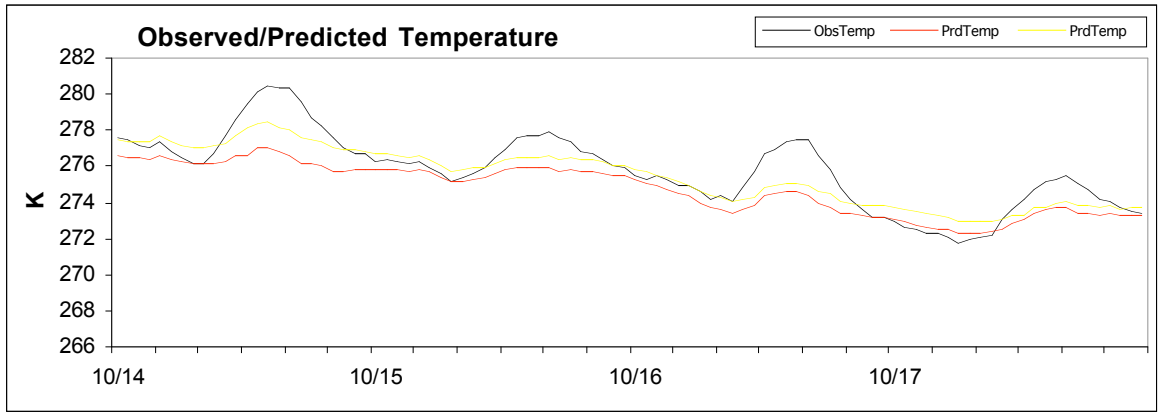


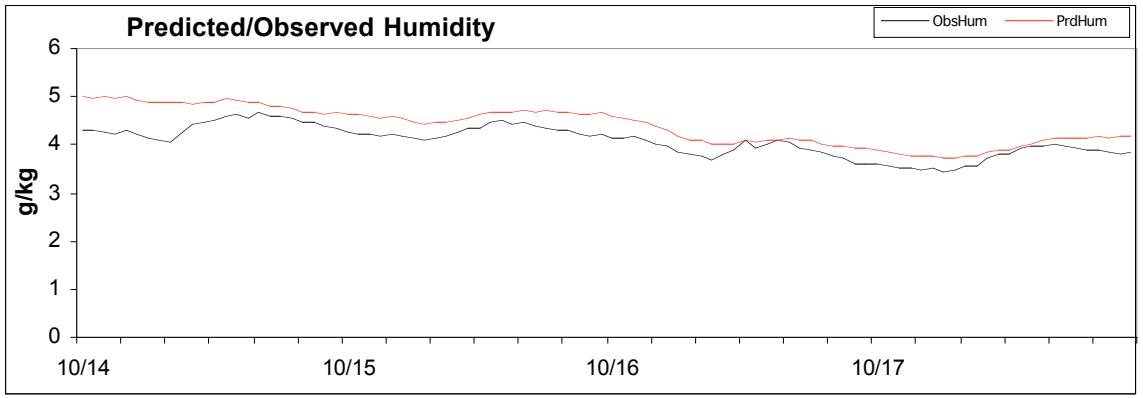
- Diurnal cycle too weak
- Daily max too low
- Cold bias



- Wet bias
- Reasonable agreement

Temperature, Humidity Time Series for 15 km Domain for October 14-18





- **Diurnal cycle too weak**
- **Cold bias**
- **Sea ice effect small**
- **Wet bias**

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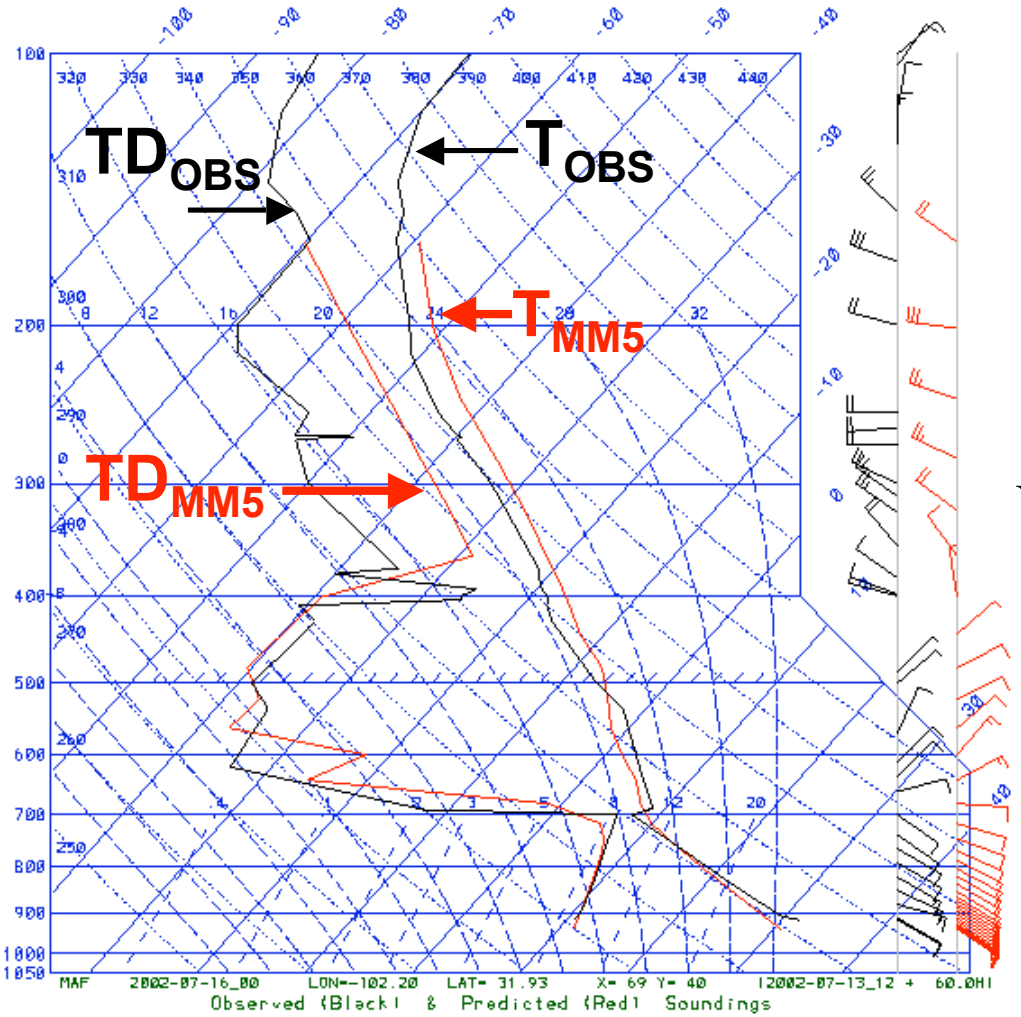
Method for Evaluating Upper Air Performance

- **Use Matthew Johnson's (IDNR) RAOB program to compare FSU observed 0Z and 12Z soundings with MM5 soundings.**
- **Compare soundings for December and July only. Examined soundings from stations in each subdomain.**
- **Analysis is based on inspection of the soundings, and is necessarily subjective.**
- Use caution in generalizing based on these results

Skew-T Diagram

Altitude

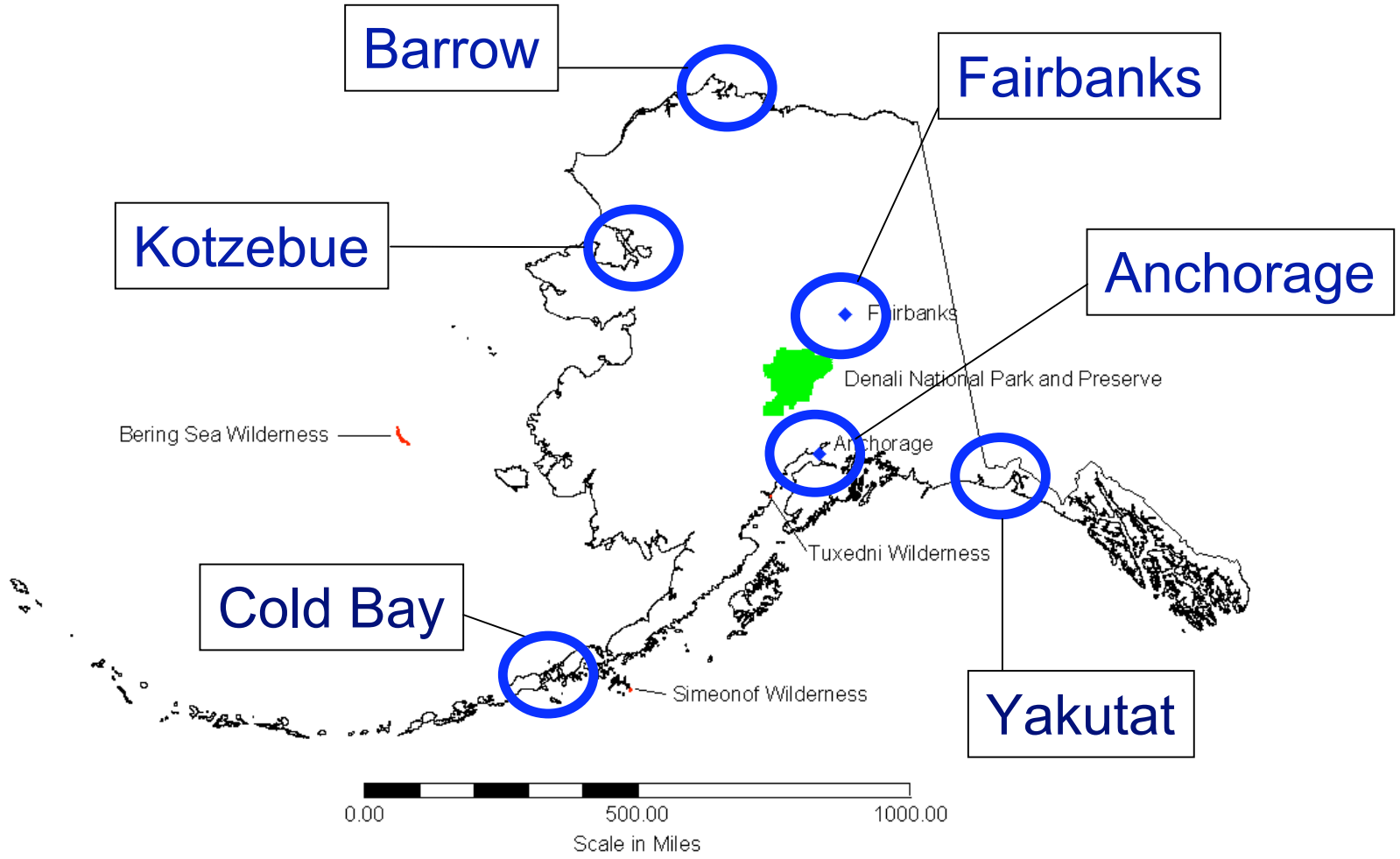
Pressure



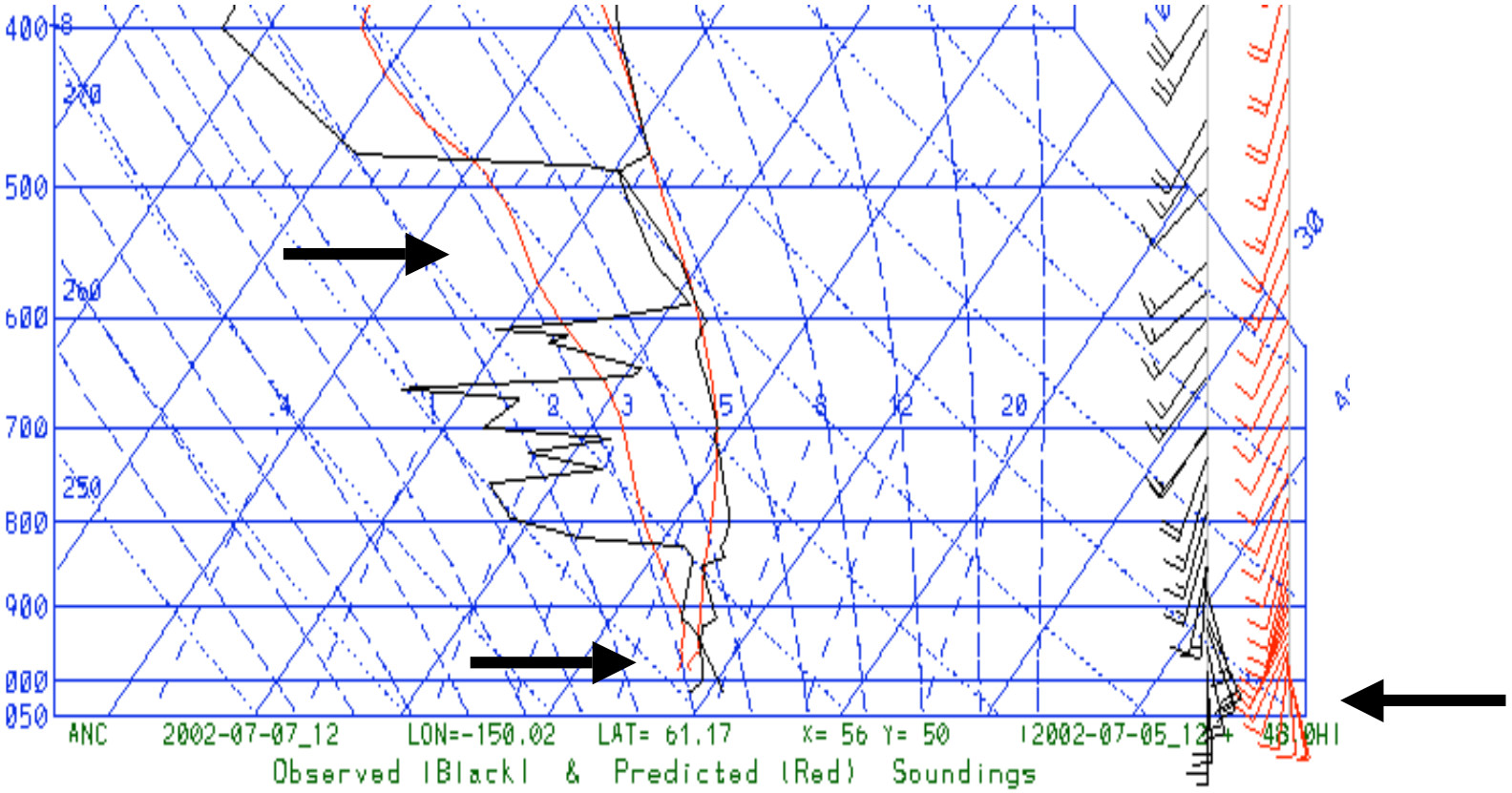
Winds

Temperature

Alaska 45 km Domain Raob Stations

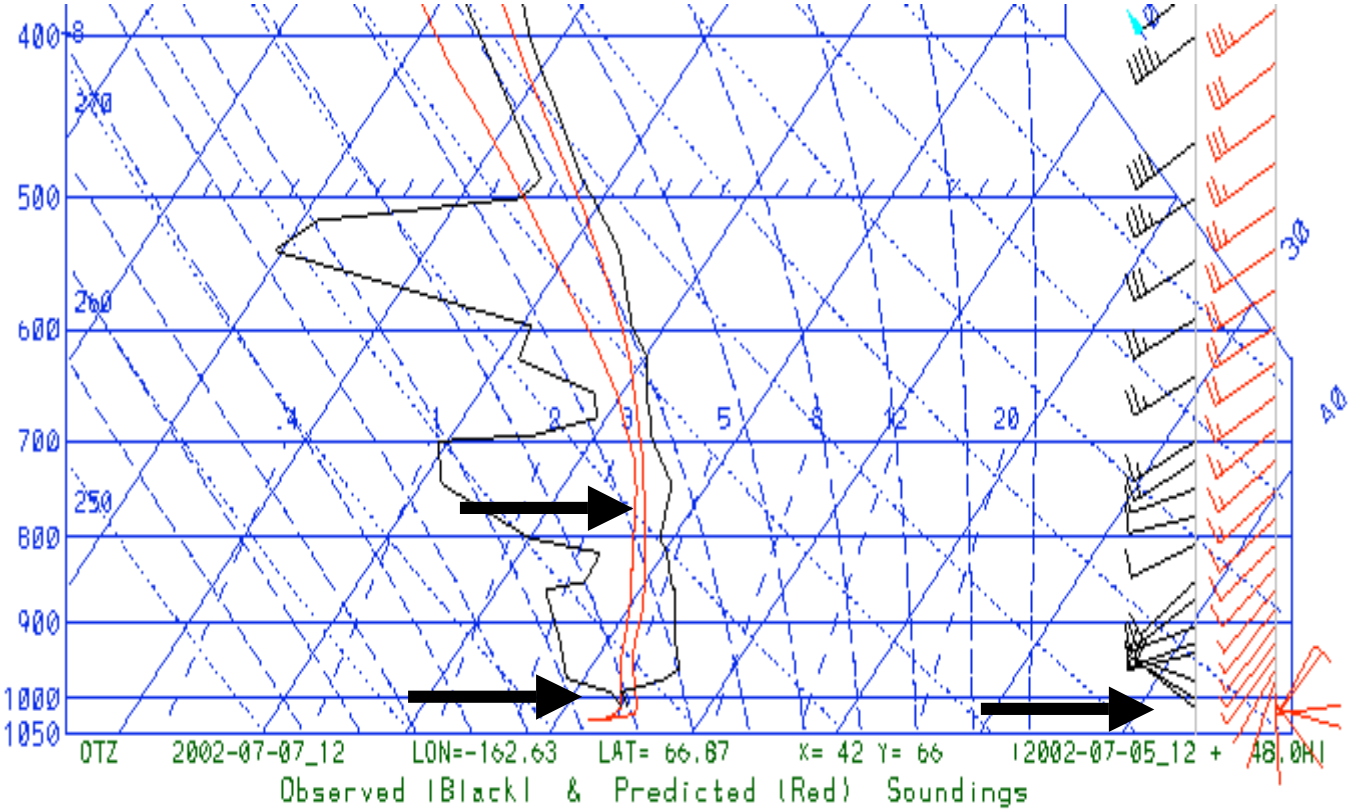


Anchorage Sounding, July 7, 2002 12Z



- Cloud deck, surface pressure, winds

Kotzebue Sounding, July 7, 2002 12Z

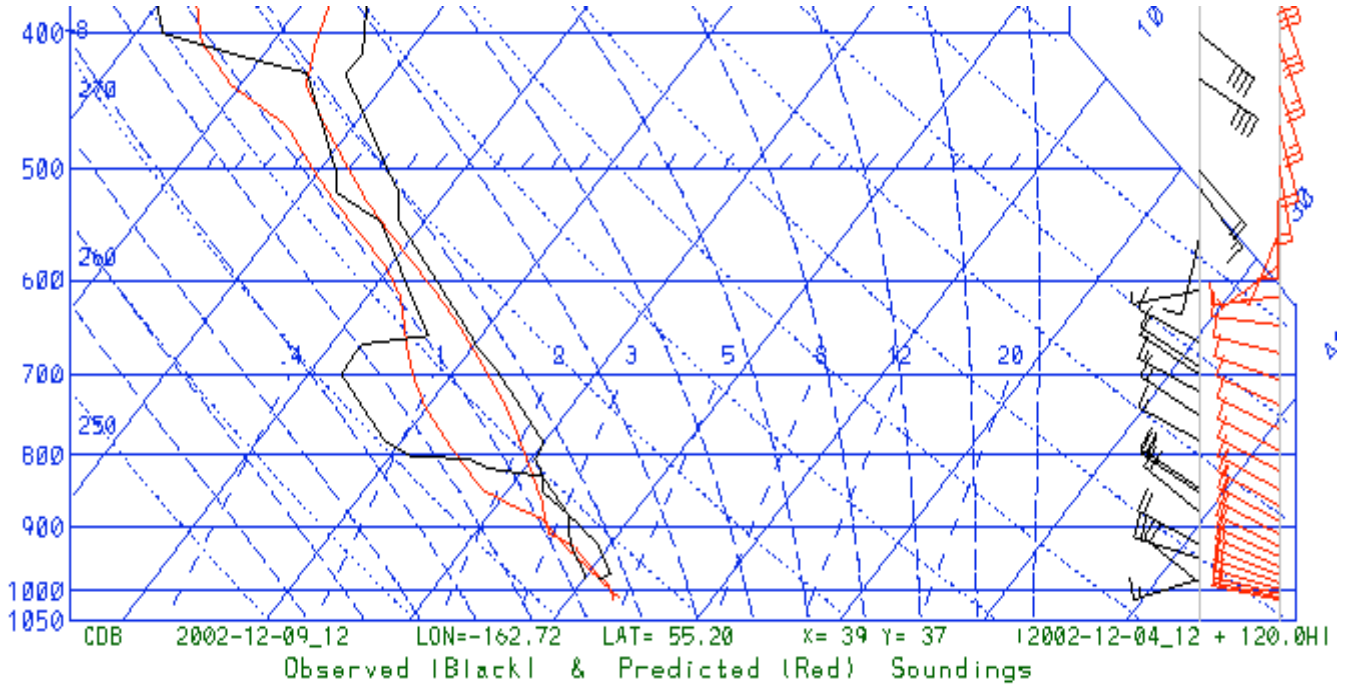


- Tendency to saturate, winds, surface pressure
- Northern part of 15 km domain

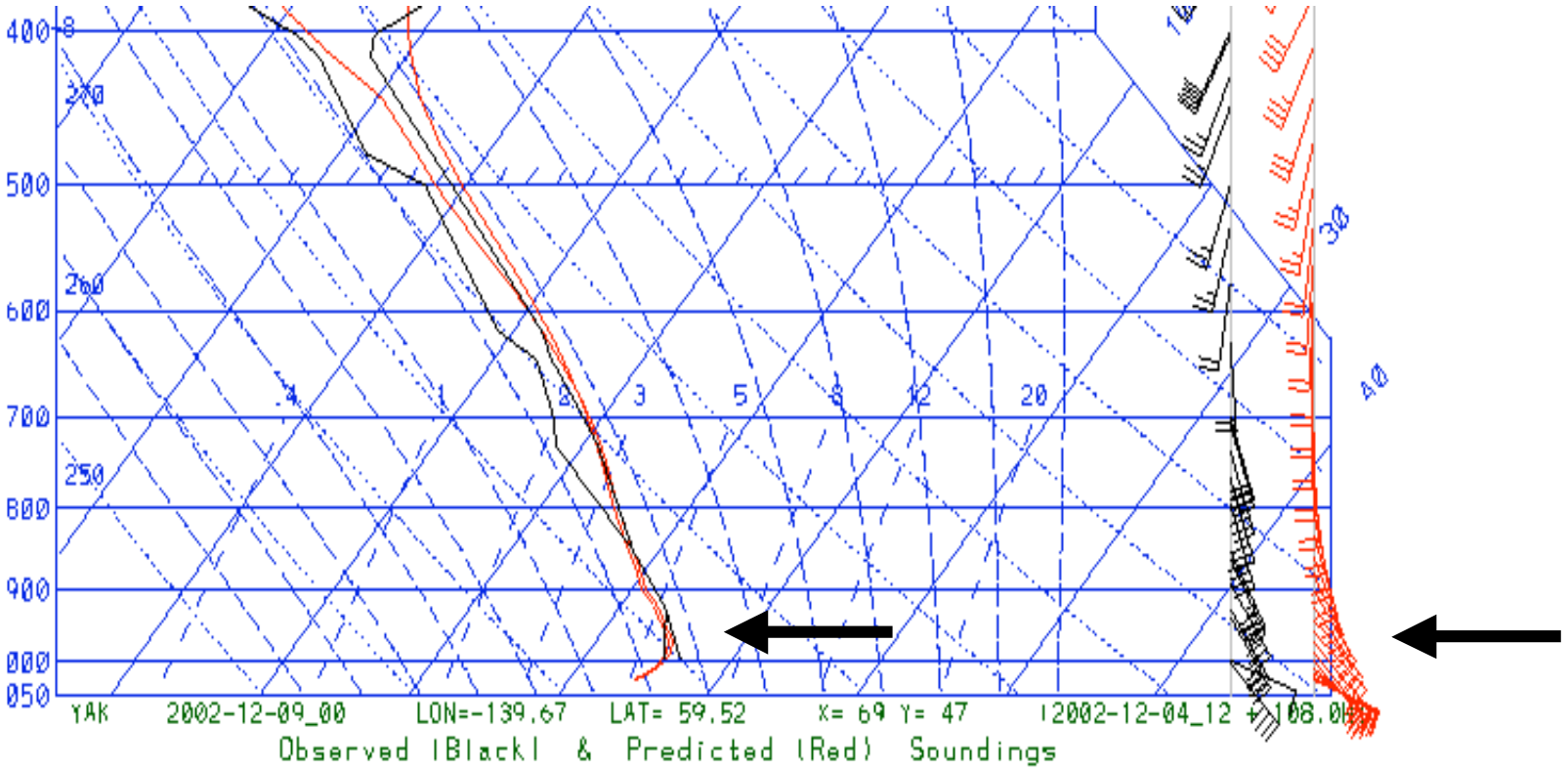
45 km July Upper Air Summary

- Southern part of domain better for T and T_d
- Some significant wind errors
- Misses fine structure in T_d profile (Clouds)
- Surface pressure mismatch
- MM5 tends to saturate more than obs

Cold Bay Sounding, December 9, 2002 12Z

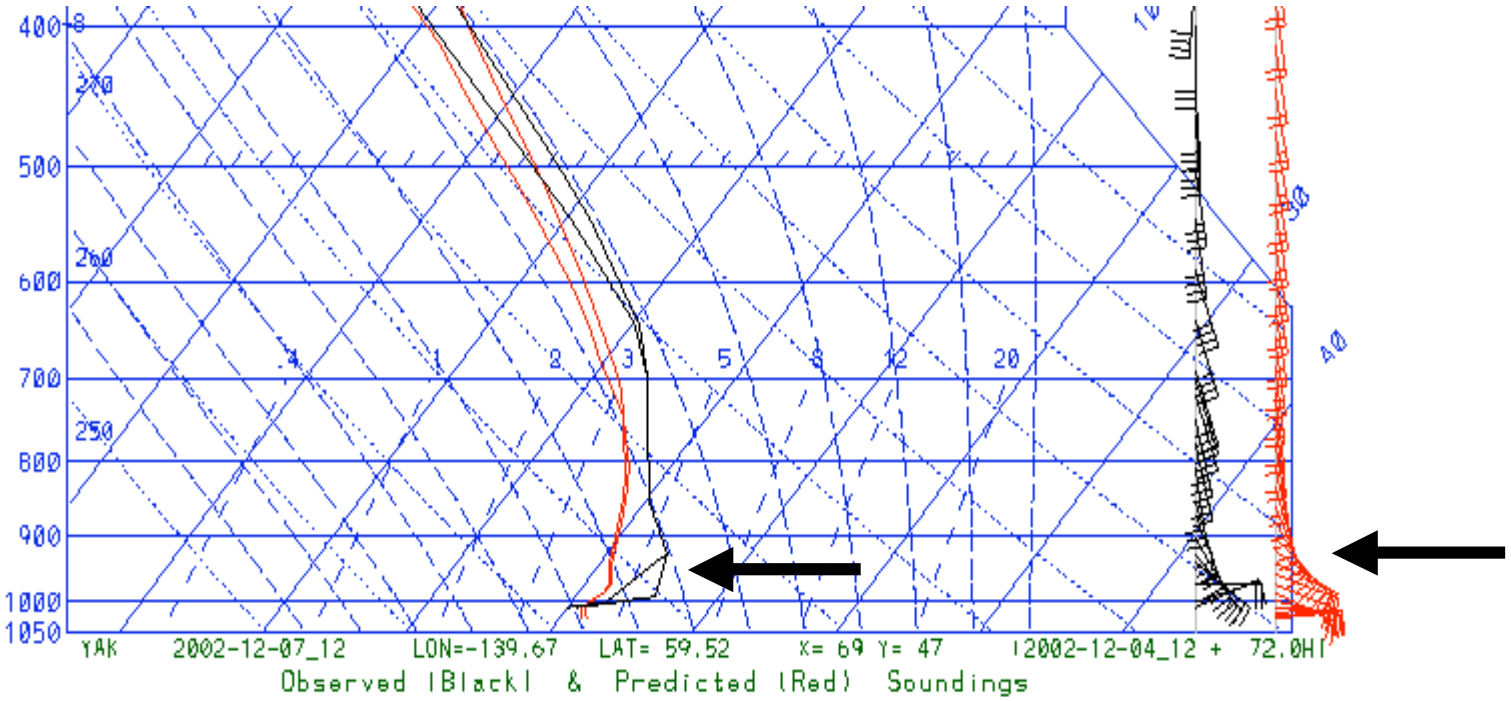


Yakutat Sounding, December 9, 0Z



- Better T profile, winds

Yakutat Sounding, December 7, 12Z



- Missing inversion, winds ok

45 km Grid December Upper Air Summary

- Overall performance better than July
- MM5 tends to saturate too much
- Winds better than in July
- Need to look at rest of year, 15 km grid